

Kinetics of Direct Oxidation of H₂S in Coal Gas to Elemental Sulfur

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Abstract

The direct oxidation of H₂S to elemental sulfur in the presence of SO₂ is ideally suited for coal gas from commercial gasifiers with a quench system to remove essentially all the trace contaminants except H₂S. This direct oxidation process has the potential to produce a super clean coal gas more economically than both conventional amine-based processes and the hot-gas desulfurization (HGD) using regenerable metal oxide sorbents followed by Direct Sulfur Recovery Process (DSRP). The objective of this research is to support the near- and long-term DOE efforts to commercialize this direct oxidation technology. The objectives of this research are to measure kinetics of direct oxidation of H₂S to elemental sulfur in the presence of a simulated coal gas mixture containing SO₂, H₂, and moisture, using 60- μ m C-500-04 alumina catalyst particles and a PFA differential fixed-bed micro reactor, and to develop kinetic rate equations and model the direct oxidation process to assist in the design of large-scale plants.

To achieve the above-mentioned objectives, experiments on conversion of hydrogen sulfide into elemental sulfur were carried out for the space time range of 0.01 – 0.047 seconds at 125 - 155°C to evaluate effects of reaction temperatures, moisture concentrations, reaction pressures on conversion of hydrogen sulfide into elemental sulfur. Simulated coal gas mixtures consist of 61 – 89 v% hydrogen, 2,300 - 9,200-ppmv hydrogen sulfide, 1,600 - 4,900 ppmv sulfur dioxide, and 2.6 – 13.7 vol % moisture, and nitrogen as remainder. Volumetric feed rates of a simulated coal gas mixture to the reactor are 100 - 110 cm³/min at room temperature and atmospheric pressure (SCCM). The temperature of the reactor is controlled in an oven at 125 - 155°C. The pressure of the reactor is maintained at 28 - 127 psia.

The following results were obtained based on experimental data generated from the differential reactor system, and their interpretations,

1. Concentration of moisture and concentrations of both H₂S and SO₂ appear to affect slightly reaction rates of H₂S with SO₂ over the moisture range of 2.5 – 13.6 v% moisture at 140°C and 120 – 123 psia.

2. Concentrations of both H_2S and SO_2 appear to affect slightly reaction rates of H_2S with SO_2 over the temperature range of 135 - 145°C at 5-v% moisture and 112 – 123 psia. However, reaction rates of H_2S with SO_2 appear to decrease slightly with increased reaction temperatures over the temperature range of 135 - 145°C at 5-v% moisture and 112 – 123 psia.
3. Concentrations of both H_2S and SO_2 appear to affect slightly reaction rates of H_2S with SO_2 over the pressure range of 28 – 123 psia at 5-v% moisture and 140°C. However, reaction rates of H_2S with SO_2 increase significantly with increased reaction pressures over the pressure range of 28 – 123 psia at 5-v% moisture and 140°C.

Publications and Presentations

Kyung C. Kwon, Santosh K. Gangwal, Janelle C. Houston, and Erica D. Jackson, Kinetics of Direct Oxidation of Hydrogen Sulfide in Coal Gas to Elemental Sulfur, presented at the DOE Annual Contractors' Review Meeting, Pittsburgh Marriott City Center, Pittsburgh, PA, June 4 – 5, 2002

Kyung C. Kwon, Santosh K. Gangwal, Suresh C. Jain, YoonKook Park, Janelle C. Houston and Erica D. Jackson, Conversion of Hydrogen Sulfide in Coal Gas to Elemental Sulfur, presented at the AIChE Annual Meeting, Indiana Convention Center, Indianapolis, Indiana, November 3 – 8, 2002.

Students Receiving Support from the Grant

Erica Jackson, Raushanah El-Amin, and Janelle C. Houston